Multimedia adaptive interactive teaching-learning environment for energy technology

Vahid Hasani Moghaddam and Ivan V. Kazachkov
National Technical University of Ukraine “KPI”, Polytekhnichna, 37, 03056, Kyiv
Royal Institute of Technology, Brinellvägen 68, HPT, 10044, Stockholm, SWEDEN
Ivan.Kazachkov@energy.kth.se http://www.energy.kth.se/

Abstract: - The computerized educational (CompEdu) platform is based on the multimedia interactive presentation of a slide show of lecturing material in a non-conventional way where instead of classical linear presentations of the important information, the material is presented in a progressive and concise way ensuring the coverage of large portions of material in shortest number of pages. In this paper, some recent results in the development and implementation of the virtual university environment are presented and discussed. Also some prospectives and advantages of this form of teaching-learning, as well as some questions of international collaboration in the field are discussed too.

Key-Words: - Computerized Education, Virtual University, Internet, Network, Interactive Learning System.

1 History and statement of the problem

The computerized multimedia educational interactive platform CompEdu contains theoretical sections in the form of e-pages for each available chapter, with a significant number of related interactive simulations, movies, animations, virtual laboratory exercises, study visits and realistic case studies. It is a platform for international collaboration in a life-long teaching-learning.

The CompEdu platform for turbomachinery has been used for lecturing, as well as for self-study by students in a several courses at the Energy Technology Dept. at KTH [1-6] and for online teaching through internet world-wide in a number of distant educational programs.

Presently the CompEdu platform is used at many other universities and companies around the world, and the number of participants of the Program is growing, e.g. recently a few new Ukrainian universities started collaboration in implementation and further development of CompEdu. The first collaboration was started between Ukraine and Sweden in this field by KNU T. Shevchenko in 2002 when the textbook was prepared by numerical methods and such course was taught by Prof. Ivan Kazachkov at the Energy technology Dept at KTH [2].

1.1 CompEduHPT multimedia platform

The beginning of the CompeduHPT project can be traced back to 1996, when the first educational program was developed at the Division of Heat and Power Technology (HPT), of the Royal Institute of Technology (KTH), Sweden. The starting platform was created based on the multimedia system Director.

The idea of the Prof. T.H. Fransson was to integrate slide shows with other educational tools such as animation, simulation, videos, case studies and virtual laboratory exercises, etc. The concept and the potential educational benefit attracted the intention of some professors and industry experts leading to the establishment of a collaborative activity around the e-learning platform [1, 7-12]. The development was carried out at KTH by a multi-disciplinary team.

The early success has encouraged developers to investigate the multimedia teaching-learning further and lead to the development of other designs. The main objective was to establish a comprehensive learning and teaching tool.

The secondary objective of the CompEduHPT platform was building the computerized tool, which could be used as an international interactive computerized platform for a global learning, in which teachers from different universities cooperate with one goal to make the learning easily accessible for students anywhere in the world (Fransson, et al., [1]).

1.2 The concept of Compedu multimedia platform

The concept of interactive CompEduHPT platform is demonstrated in Fig.1, where it might be observed that the design of the main pages has been given much attention in order to present an easily understandable material and to keep students’ interest along the chapter providing them with the possibility to adapt their learning process to their needs.
1.3 The functionality of Compedu platform

Some more information to understand the idea of Compedu platform and its functionality is presented in Fig. 2:

Fig. 2. Outline of the Compedu platform

Then from the main slide show, a range of background information and features such as history, multilingual glossary, and browser, etc. is possible for access through a tool bar that appears in the bottom of the page (see Figs. 3, 4):

Fig. 3. The main page in the interface of the Compedu book “Numerical Calculations”

Fig. 4. Popup as a hyperlink to the word in the main page explaining material in detail.

1.4 The Compedu material on numerical methods in energy technology

For example, the Comed material on CFD contain first of all short thorough review of the basic course on numerical continuum mechanics that is taught in the last two years of study in mechanical engineering faculties at the most universities.

Conscious of the extensive literature on computational thermofluid analysis, the authors tried to present a self-contained treatment of both theoretical and practical aspects of boundary-value problems in numerical continuum mechanics.

In this book and corresponding interactive computerized material, first some basic knowledge of university-level mathematics and fluid dynamics is given. To understand the material, the student has to know some basics of differential and integral calculus,
differential equations and algebra. For the advanced reader these chapters can serve as a training manual.

This material may be certainly used as guide for the practical development, study or just use of any particular numerical method or algorithm, etc. In each CompEduHPT chapter on numerical methods and in the e-book, some typical problems and exercises on the practical applications and for the practical work on a computer are proposed, and it is intended that these may be done simultaneously.

Execution of the tasks and exercises will contribute to a better understanding of the learning material and to a development of a student’s practical skills. The main difference between traditional teaching and the use of CompEduHPT for learning and teaching is that for the latter case understanding means being able to apply knowledge in practice.

It is often better to prove a result to oneself rather than to read about how to prove it (although both methods of learning are of course useful).

2 Advantages and problems of the CompEdu platform

2.1 The Compedu material on numerical methods in energy technology

The educational materials are developed and tested by students, teachers, any other persons by companies of the sponsors of CompEdu, also by collaborators and afterwards the best materials are shared to achieve the most promising results in education. For example in the block of the multimedia lectures and interactive exercises for graduate students or advanced undergraduates studying numerical methods for the solution of partial differential equations governing fluid dynamics and heat transfer processes there are applied a number of different methods.

Although the majority of the methods presented were introduced in either the applied-mathematics or fluid dynamics literature, the focus is not on the details of various flow and heat transfer models but on the fundamental numerical methods, best practice guidelines for numerical solution of specific boundary-value problems for partial differential equations, which have applications in a wide range of scientific and engineering disciplines. For example, energy technology, nuclear power safety, reactor technology, chemical technology, and so on.

With account of the above-mentioned, it is important in the teaching-learning process to follow both at the same time – understanding the physical model and the best way to realize it on computer performing numerical experiment and then analyzing the results obtained.

Interactive system allows showing all the process clearly and repeatedly.

2.2 The new ideas and development of the teaching methodology

The CompEdu platform is also good room for innovations including teaching philosophy and methodology. For example, recently at the EGI/KTH the new option of CompEdu was invented, which was named the page “Where I am”. First the idea was just to help student in orientation inside the big chapters so that not to forget where he has started with when he is in the process of studying the complex subjects like the modern numerical methods for complex real problems.

This tool helps student in regularization of the learning material and building the simple step-by-step learning process. Every time when student feels he is losing the main line of the material studied, he may click on the button to see clear simple picture about all his process of study and understand where he is and where to go further. Such simple idea is very deep and valuable because philosophically everyone is having troubles in the learning process when he feels that lost the whole consequence or some details which make him confused and became impediment in understanding the material. With this simple mean student in CompEdu feels better.

In the preparation of teachers, there is still another problem, and in examining teaching principles and practices, we cannot agree on whether teaching is a science or an art. Some readings say that this is a hopeless dichotomy, because the real world rarely consists of neat packages and either/ or situations.

A science of teaching is attainable because it implies that good teaching is possible by closely following rigorous laws that yield high predictability and control. We analyzed different methodological factors what directly influence a quality of students’ knowledge and skills.

Methods of numerical problems solving (PS) is another important part of the science curriculum for the secondary school and university that can improve or lower the quality of the educational process especially in Physics, Chemistry and Mathematics. It’s known that the PS of numerical problems (NPs) is a difficult task for students of secondary (high) school and university.

For many science teachers explaining the ways of PS of NPs in the class is a difficult task, too, and the methodology of resolution of the problems cannot be a task separated from other objectives of science teaching. It is a difficult matter, but it is connected in a systemic way to all other objectives and major subsystems of the curriculum.

There have been a lot of different papers about PS (Shatalov 1980; Harron 1996, De Jong 1991; Hayes
Recently developed the new page in web CompEdu “Where I am” after careful analysis seems to be methodologically similar to the tables of the teacher-methodologist V. Shatalov, whose experiments and great success with enforcement of the school teaching in the 70-th in the former USSR wondered by the unbelievable good results.

The CompEdu platform is permanently under development and modernisation. The new tools in Micromedia Director were developed, e.g. Chaptor Creator. It allows developing the new CompEdu chapters, which can be saved in cast file format, and modification of the existing ones. This tool is proposed to the developers of CompEdu chapters from around the world, which are in collaboration with CompEdu team.

The main room is also under improvement to get more functionality with the shelves and books, e.g. add and remove books and shelves easily, have possibility to select books by user’s desire, make copy protected shelves, etc.

The common view of a new Main room is given in Fig. 5. It is completely different from old one, which was done in Director and operated with graphical files.

To analyze and to look for the best methods of explaining, it is necessary to take into account the typology of NPs in Physics, Chemistry and Mathematics. These problems can be of the basic level of difficulty or more complex (for example, of mixed types which require deep analysis and other high order cognitive skills).

The most difficult of these NPs are Olympiad problems for secondary school and research problems of university level. Of course problems can be classified from different points of view; for example, taking into account the difficulty, as we mentioned before: A. Typical problems. They are generally the easiest problems of the course, for which it is necessary to use only one of the chemical concepts. B. Intermediate problems, whose solution requires only two basic concepts.

Many of these problems come from different topics and students don't always have the algorithms to solve them. C. Difficult problems, which require the application of high level abilities and many concepts of different topics. There is a good classification of numerical problems on the basis of objectives, data and methods.

The PS is always a very complex psychological process that implies the understanding of the language expressing the problem, the interpretation of the data, and the understanding of the scientific concepts involved in the solution.

In addition the student must have the ability to apply the necessary mathematical operations to look for the solution. For successful PS, it is very important for students to understand well the theoretical concepts of the topic, with the strong connections to the NPs of the current theme of the course.

Teaching practice shows that students have a lot of difficulties with mathematics because the solution of the NPs in the different courses presupposes the important requirement that the students should have previous knowledge and abilities in the respective topics of mathematics. Some students can not understand well which numerical data correspond to the main objectives in the given problem, and the correct relationships of these data with the important concepts. To help them, the teacher can apply an old recommendation for the classes of physics and chemistry: to make a visual emphasis of numerical data.
2.3 The collaboration in common developments

The collaborators work on development of the new teaching materials where they feel they are good, create the new tools for improvement of the platform, also perform study and make experiments on the teaching methodology.

Collaborators first learn features of the CompEdu and experiment with the students who can construct a model and run simulation by choosing special graphical units and establishing connections between them from a special “list of links”. They do believe that such tool will increase present simulation tools, which are required more and more for the intensive interactive educational process.

2.4 Web based version of CompEdu

The Swedish netuniversity organized in 2001 started broad spreading of the web based distant education. After 2002 the CompEdu platform started to transform for the internet version, so called the webCompEdu.

Presently both, DVD and internet CompEdu versions exist. The first is used for self-learning and teaching in the classes, the second version is mainly used for the interactive Internet teaching and learning. A few distant programs are successfully run at the EGI/KTH. By this, very important part is simulation and calculation exercises, which help the student in applying his knowledge for solution of practical tasks.

3 Simulations, animations, case studies, calculation exercises in CompEdu

3.1 Simulations

The first twenty simulations for the webCompEdu have been successfully developed by Ukrainian collaborators from NTUU “KPI” and NSU named after Gogol and proved by colleagues at the EGI/KTH. Some of them are ready to implement inside CompEdu, the other ones are under testing by teachers and students before their delivering to CompEdu platform.

With account of the comments made by KTH team they are modified and improved to satisfy the requirements. Many simulations and animations are still waiting for the development, for example the following simulations:
- C5 Real Gas Turbine Calculation, Simulations: Real Gas Turbine Calculations
- 5 simulations are available for download and run locally in a Microsoft Windows-based computer:
  - Simple gas turbine cycle
  - Regenerative gas turbine cycle
  - Reheated gas turbine cycle
  - Intercooled gas turbine cycle

For example, in Fig. 6 there is shown such simulation for studying the simple gas turbine, ideal cycle. Buttons allow changing parameters and to the right it is observed in graph, which influence is from each of varying parameters:

![Fig. 6. Simple gas turbine: ideal cycle](image)

3.2 Animations

The animations can be developed similar to the simulations done before. In the future collaborators can develop also: HISTORY, GLOSSARY and GALLERY.

In the DVD version the simulations were developed and presented for demonstration of different working processes and facilities. Also a number of numerical simulations for different systems have been done in a form of animated calculation results, which help to understand the process more in deep, for example studying the evolution of the non-stationary processes.

3.3 Case studies and Study visits

The Case studies and Study visits are under development and improvement in the platform. Concerning the big Värtan Trigeneration Plant it is also in principle available to do if needed. Study questions and Pictures are done easily but there are a lot of them (1050 totally!).

In CompEdu there is each picture in its chapter. In the Internet version all pictures must be collected in one file or divided by book shelves because they are a lot totally. The Equations are 13 totally and they may be developed also with a searching by key words.

3.4 Development of the CompEdu platform

An electronic learning and teaching platform for turbomachinery has been presented. It is believed to be the first complete electronic textbook in the field, which
covers the main essential ingredients in a modern educational environment, such as:

- presentation of the basic theory in an electronic, interactive form together with printed versions of the material in the classical form,
- “pop-up” for further very detailed information,
- interactive simulations with guided messages,
- case studies, movies and animations,
- virtual laboratory exercises,
- interactive exercises, quizzes and study questions.

This type of interactive educational platform can hopefully serve as a base for a better teaching-learning environment in a global life-long education.

It is implemented at the EGI/KTH both for class and distant teaching-learning and in some parts also at many other universities and companies. It is developed towards improvement both the programming platform/tools, as well as quality and quantity of the books and chapters.

4 Conclusions

The CompEdu platform is successfully used by collaborators as world-wide best teaching and learning tool both on DVD and web based.

The Ukrainian team has performed analysis of the current CompEdu status and made proposals for further developments for the web version of CompEdu.

References: